Table 2–33. Consequences of Uncertainty

	EIS Uncertainty/Assumption	Consequences
1.	**Ground Water and Site Conceptual Model Assumptions** On the basis of ground water modeling and the current site conceptual model, the EIS presumes that a target near-river ground water remediation goal of 3 mg/L ammonia can be achieved for the on-site disposal alternative and for all off-site disposal alternatives, and that this goal will result in sustained post-remediation surface water concentrations of 0.6 to 6 mg/L total ammonia after 75 to 80 years of active ground water remediation. (Note: River water quality would be acceptable within 5 years after implementation of ground water remediation because of plume interception). The EIS presumes that without catastrophic events, this surface water concentration would be sustained for at least 1,000 years after completion of ground water remediation for the on-site alternative and permanently for the off-site alternative. Uncertainties are associated with the ground water modeling input parameters and associated model results, including contaminant distribution coefficients, first-order decay rates for ammonia, pore fluid concentrations, flow parameters, and the efficiency of natural flushing.	The consequences of using an erroneous value for the ground water flow and transport input parameters apply to all the alternatives. At the **upper limit of the uncertainty**, the actual concentrations of ammonia could be at least 10 times greater than predicted. Therefore, it is possible that the on-site disposal alternative would never achieve the 3-mg/L ammonia target goal. For the off-site disposal alternative, there is no uncertainty that the target goal would eventually be achieved, because the tailings, which are the source of some of the ammonia, would be removed. However, there is uncertainty associated with the time frame required for the ammonia concentrations to attenuate to the target goal. If actual ground water concentrations are 10 times greater than predicted, the time frame to achieve protective concentrations in the surface water could be greater than the predicted 75 years for the off-site disposal alternative. If the target goal of 3 mg/L ammonia in ground water could never be achieved for the on-site alternative or could not be achieved in 75 years for the off-site disposal alternative, DOE could be required to continue active ground water remediation for an indefinite period beyond the projected 75 to 80 years to maintain protective surface water quality. The annual generation of 6,600 tons of RRM, the estimated $906,000 in annual ground water treatment costs, and the institutional controls associated with ground water remediation activities would all continue for an indefinite period beyond the currently projected 75 to 80 years. At the **lower limit of the uncertainty**, the actual ammonia concentrations could be at least 2 times lower than predicted. Therefore, it is possible that even the No Action alternative could achieve the 3-mg/L ammonia target goal. It is also possible that the on-site and off-site disposal alternatives could achieve the 3-mg/L target goal earlier than the predicted 75- to 80-year time frame, consequently resulting in lower costs for ground water remediation than estimated.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
2.	**Surface Water Compliance Standards** Partly on the basis of past experience, it appears reasonable to DOE that protection for aquatic species would be achieved at total ammonia concentrations in surface water of (1) 3 mg/L, representing the lower limit of the range of the acute criteria that would be met everywhere in the river (assumes no dilution) and (2) 0.6 mg/L, representing the lower limit of the range of the chronic criteria that would be met outside a mixing zone (assumes dilution). Note: Because of plume interception, total ammonia concentrations in the river would be less than these levels within 5 years after implementation of ground water remediation. However, DOE acknowledges that the Utah Department of Environmental Quality disagrees with this position regarding the applicable acute and chronic compliance standards and whether a chronic mixing zone would be appropriate.	Because ground water remediation is proposed under all action alternatives, the consequences of the uncertainties associated with applicable compliance standards apply to the on-site and all off-site disposal alternatives. However, the consequence of this uncertainty is greatest for the on-site disposal alternative. If DOE's assumption regarding a mixing zone is incorrect, and a mixing zone does not apply, then the 0.6- to 6-mg/L chronic criteria for ammonia concentrations in surface water would be required to be met everywhere in the river (no dilution). The length of time required for active ground water remediation would increase in order to achieve a lower ammonia concentration in the ground water and the identified applicable compliance standard in surface water. To achieve 0.6 mg/L would likely require about 90 (rather than 75) years for the off-site disposal alternative and more than 200 (rather than 80) years for the on-site disposal alternative. The annual generation of 6,600 tons of RRM, the estimated $906,000 in annual ground water treatment costs, and the duration of institutional controls associated with ground water remediation activities would all be prolonged accordingly.
3.	**Tailings Characteristics (Nonradiation)** The proposed conceptual designs and schedules for removal of the mill tailings pile under the off-site disposal alternative are based on DOE's experience and assumptions about the physical and chemical characteristics of the tailings pile. These assumptions, which include the tailings moisture content and driability, particle size distribution, and the concentrations and distributions of organic and inorganic contamination, are based on field characterization studies, DOE's experience with other UMTRCA sites, and historical Moab site data. However, DOE acknowledges that there are uncertainties in these assumptions. These pile characteristic uncertainties could affect final surface remediation cost and schedule, but would not affect the ability of an engineered design to ensure that the stability requirements of 40 CFR 192 were met.	The consequences of the uncertainty about the physical and chemical characteristics of the tailings apply primarily to the off-site disposal alternative because under on-site disposal, the pile would remain largely undisturbed. However, some of the uncertainties affect the three transportation modes differently. If assumptions regarding **average moisture content** are low and the tailings are less driable than assumed, longer drying times would be required, and the schedules for the truck and rail transportation modes could be longer than projected. Associated costs would increase accordingly. However, prolonging the duration required for truck transport could also have the positive impact of reducing the daily truck traffic volume. Moisture content uncertainty would not affect the slurry pipeline because drying would not be required. If assumptions regarding the **average particle size of the tailings materials** are low, additional mechanical processes could be required to reduce their size. This would negatively affect cost and schedule estimates. The slurry pipeline option would be especially sensitive to this uncertainty because the material must be sieved to a specified mesh for slurry formation. The rail option is also sensitive because materials must be small enough to be loaded and transported on a conveyer for loading gondola cars. Additional truck transport could be required under the rail or pipeline options if size distribution estimates were wrong. This would result in more truck traffic and possibly more accidents than the EIS projects. For all alternatives, if additional mechanical size reduction were required, there would be a concurrent increase in worker exposures to contaminated dust.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
4.	**Mass and Volume of Excavated Contaminated Soil and Reclamation Soil** Under the on-site disposal alternative, approximately 234,000 tons (173,000 yd^3) of contaminated soils at the Moab site would be excavated and disposed of with the tailings. Under the off-site disposal alternative, approximately 234,000 tons (173,000 yd^3) of contaminated site soil at the Moab site and approximately 566,000 tons (420,000 yd^3) of contaminated subpile soils would be excavated. For all action alternatives, these materials would be disposed of in the same manner as the tailings. The EIS assumes that 320,000 to 425,000 yd^3 of clean reclamation soil (10,000 to 13,000 shipments from Flow Wash) would be needed to backfill the Moab site to an approximate average depth of 6 inches. However, DOE acknowledges uncertainties associated with these estimates.	Because off-pile contaminated soil excavation and backfilling is proposed for the on-site and all off-site disposal alternatives, the consequences of the associated uncertainty applies to all action alternatives, but the extent of some of the consequences varies; the off-site truck disposal consequences are the most extensive. Under the off-site disposal alternative, if DOE has significantly underestimated the volume of contaminated off-pile soil that would need to be excavated, there would be a commensurate increase in the amount of material to be transported to an off-site disposal location. Although the potential increase in transported volume is not expected to be large compared to the existing pile volume, it would increase the projected numbers of truck and rail shipments, fuel use, truck traffic and accidents (truck transport), population exposures to radiation, water consumption (especially for the slurry pipeline option), and transportation-related costs and schedules. For all action alternatives, there would be an increase in worker exposure to contamination associated with the deeper excavation and more suspended contaminated dust. Under the on-site disposal alternative, there would be a commensurate increase in the amount of material to be disposed of in the Moab pile (surcharge). This could increase the required amounts of radon barrier and cover borrow material, which would increase land disturbance at borrow areas and increase associated truck traffic and fuel-use impacts. Under all action alternatives, if more than the projected number of shipments of clean backfill from borrow areas were necessary, there would be a proportional increase in disturbed land at borrow areas and a proportional increase in borrow truck traffic, fuel consumption, traffic accidents, and truck-related adverse noise.
5.	**Residual Subpile Contamination** Even after subpile soils are removed to a sufficient depth to meet all radiological cleanup standards in 40 CFR 192, residual contamination could remain below the depth of remediation at depths that could affect ground water quality.	This uncertainty applies only to the off-site disposal alternatives and applies to each of them equally. The primary consequence of this uncertainty is that the off-site disposal alternatives do not guarantee removal of all potential sources of mill-related ground water contamination. Achieving and maintaining post-remediation protective river water quality could require continuing with active ground water remediation for an indefinite period beyond the projected 75 to 80 years. The annual generation of 6,600 tons of RRM, the estimated $906,000 in annual ground water treatment costs, and the institutional controls associated with ground water remediation activities could all continue for an indefinite period beyond the currently projected 75 to 80 years. Alternatively, the consequence could be the need to excavate subpile soils to a depth that is greater than currently projected; in that case, the consequences would be similar to those described in number 4.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
6.	**Extent of Contaminated Vicinity Properties** The EIS assumes the need to remediate 98 of 130 vicinity properties and that approximately 39,700 tons (29,400 yd^3) of material would be transported to the Moab site over a period of 1 to 3 years for subsequent on-site or off-site disposal with the tailings.	Because vicinity property remediation is proposed for the on-site and all off-site alternatives, the consequences of the associated uncertainty apply to all action alternatives. If additional vicinity properties required remediation, the labor, volumes, and impacts associated with their remediation would increase proportionally. All of these consequences would affect all action alternatives, although the cumulative impact on traffic in central Moab would be most severe for the White Mesa Mill truck transportation alternative, under which truck traffic in central Moab is currently estimated to increase by 127 percent. If vicinity property transport trips were to double, truck traffic in central Moab would increase by 135 percent under the White Mesa Mill alternative. The estimated mass of vicinity property material requiring remediation (39,700 tons) is less than one third of 1 percent of the estimated mass of the uranium mill tailings pile. Consequently, even if the mass of vicinity property material requiring remediation were twice or three times what DOE estimates, the impacts on the final dimensions of the disposal pile and, in the case of off-site transportation alternatives, on the total numbers of off-site shipments would be minor. The major consequences of this uncertainty would be associated with (1) the local traffic and traffic on US-191 required to transport the contaminated vicinity property material to the Moab site, (2) the volumes of required backfill material and the associated traffic. The EIS estimates that if all vicinity properties were remediated in 1 year, it could require 48 daily trips on US-191. This traffic volume, and in particular the impact on the highly congested area of central Moab, would increase proportionally if additional vicinity properties required remediation. There would also be a proportional increase in the exposure of workers and the public to contamination and the general disruptions and displacements associated with the remediation activities.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
7.	**Worker Dose Rates and Exposure Times** Estimates of the length of time that would be required to excavate the pile and transport it to an off-site location (off-site disposal alternatives) assume that the level of radiation to which workers would be exposed would allow workers to work a 10-hour shift. There are, however, uncertainties about the dose of radiation to which workers would be exposed once the interim cover was removed and pile relocation operations were begun.	The consequences of this uncertainty apply primarily to the off-site disposal alternatives because under the on-site disposal alternative the tailings pile would not be excavated, although there would still be emplacement of contaminated soils (surcharge), material from vicinity properties, and a permanent cover. In the EIS, worker dose estimates were based on the highest radiation levels and radon concentrations measured when the Moab pile was excavated to construct an evaporation pond. However, if radiation levels or radon concentrations are higher, and if under the off-site disposal alternatives it were determined that some or all workers could not work a full 10-hour shift because of radiation levels, there would be several possible management strategies, including (1) using more cumbersome personal protective equipment, (2) augmenting the work force to reduce the daily dose to individual workers while maintaining the current schedule, or (3) prolonging the schedule to allow the same number of workers to be exposed to reduced daily doses. If the level of potential worker exposure required DOE to implement any of these strategies, the duration of the project could be longer than currently projected. An augmented workforce would exacerbate commuter traffic and socioeconomic and other workforce resource demands. More extensive radiation monitoring and personnel decontamination facilities could be required. It is unlikely that this uncertainty would adversely affect ground water remediation schedules or the projected time for achieving acceptable river water quality.
8.	**Extent of Cultural Resources and Traditional Cultural Properties** The EIS acknowledges uncertainties in the number and density of potentially affected cultural resources and traditional cultural properties. It is possible that detailed surveys or traditional cultural property studies that would be conducted for the preferred alternative identified in the final EIS would identify a significantly richer cultural resource than indicated by existing, less detailed, or adjacent surveys.	Although this uncertainty affects all alternatives to some degree, the consequences would be greatest for the White Mesa Mill alternative, in particular for the White Mesa Mill slurry pipeline option. The likelihood that additional traditional cultural properties (not identified in the draft EIS) would be identified after completion of site-specific surveys and studies is extremely high. Results of required cultural resource surveys and traditional cultural property studies might show that the White Mesa alternative could be more costly to implement because of the severity of impacts to newly discovered cultural resources.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
9.	**River Migration** On the basis of river morphology, soil-formation evidence on terraces bounding the valley, and lack of terraces within the valley, DOE has concluded that Moab Valley is subsiding because of salt dissolution and that the river will occupy the lowest portion of the valley. Evidence presented in DOE's river migration report suggests that the valley is subsiding more rapidly in areas away from the pile, which will force the river to move southeastward away from the pile. However, DOE acknowledges the uncertainty in this interpretation and that the State of Utah disagrees with DOE's position. The State argues that the river has migrated widely across the tailings and millsite area in the geologic past and that DOE should take the conservative approach and assume that river migration could impinge on and undermine the existing tailings pile in the future. DOE is continuing to work with the State and the other cooperating agencies to develop additional information to narrow the uncertainties regarding river migration.	The consequence of this uncertainty applies to the on-site disposal and No Action alternatives. The uncertainty has no significance under the off-site disposal alternative because the pile would be removed. DOE's analysis supports the position that any potential river migration toward the pile would not occur as a catastrophic event but rather gradually in small increments, allowing ample time to implement sufficient engineering controls that would adequately mitigate river migration for the regulatory time frame of 200 to 1,000 years specified in 40 CFR 192. Preliminary evaluation of appropriate engineering mitigation suggests that a riprap wall could be constructed between the river and the disposal cell to deflect river encroachment, in the unlikely event that it occurred. The potential costs for such a mitigation effort have been roughly estimated to range from $0.5 million to $2.0 million, depending on the location and nature of the encroachment, the size of materials required, and method of construction. In addition, it is likely that these costs would be spread over many years and possibly even decades, depending on the nature and rate of river encroachment. If river migration and encroachment were to occur to a great degree, significantly lessening the transport distance from the disposal cell to the river, surface water ammonia concentrations and concentrations of other contaminants of concern could revert to nonprotective levels, and additional engineered remedies or pile relocation could be necessary to meet UMTRCA requirements, potentially increasing program costs by tens to hundreds of millions of dollars. At the extreme, perpetual treatment or mitigation might be required, or the pile would have to be relocated after all on-site reclamation efforts and costs had been committed.
10.	**Catastrophic Floods** The EIS assumes that a catastrophic flood event (300,000 cubic feet per second [cfs], the NRC-specified Probable Maximum Flood [PMF]) will occur no more than once in 500 years. Further, during flood events that exceed bank-full flow capacities of the Colorado River, most of the flow and flow energy are dissipated in the Matheson Wetlands Preserve away from the tailings pile. However, the possibility of a catastrophic flood cannot be eliminated because part of the Moab site tailings impoundment is located within the 100-year floodplain of the Colorado River and within the floodplain of the PMF of both the Colorado River and Moab Wash. The 100-year floodplains for Moab Wash and the Colorado River occupy over one-third of the Moab site. During a 100-year flood event, it is estimated the water level would be 3 to 4 ft above the base of the tailings pile. The floodplain area for the Colorado River extends the length of the eastern site boundary from the river's edge to distances ranging from 500 to 1,200 ft west and is approximately 10 ft above the average river level.	The consequence of this uncertainty applies to the on-site and No Action alternatives. The uncertainty has no significance under the off-site disposal alternatives because the pile would be removed. If 20 to 80 percent of the tailings pile were washed into the river, it would have serious adverse impacts on the riparian plant and animal life and would affect the health and safety of residents along the river and of river guides who may spend up to 50 days on the river in a given year. Such a flood event could also affect the tourist economy of Moab if users of the river corridor avoided the area after such an event.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
11.	**Shallow Ground Water Discharge/Matheson Wetlands Preserve** DOE site investigation results indicate that the shallow ground water plume in the upper fresh-to-brackish zone is discharging to the west bank of the river. Similarly, this upper fresh-to-brackish zone is discharging from the Matheson Wetlands Preserve to the east bank of the river. Evidence that ground water is discharging to the river from both banks and that the river essentially acts as a barrier to shallow ground water flow beneath the river is presented by the ground water elevation contours shown in the SOWP (DOE 2003b). However, DOE acknowledges that the University of Utah and the State of Utah disagree with this interpretation and have reported that shallow ground water and mill-related contaminants could be traveling in the brine zone under the river to areas in the Matheson Wetlands Preserve and beyond.	At the upper limit of the uncertainty, the long-term presence of the tailings pile could result in a perpetual source of contaminants that would prohibit achieving protective surface water quality criteria on one or both sides of the river and could result in perpetual ground water remedial action or a perpetual, but limited, adverse impact in the surface waters directly adjacent to the site. At the lower limit of the uncertainty, the long-term contribution of the tailings would be an insignificant impact to the surface water quality and would not require a different scope or magnitude of ground water remediation and therefore would not affect decision-making.
12.	**Future Land Use** Because of uncertainty regarding the success of surface remediation and the possible use of "off-pile" areas of the site to support ground water remediation for 75 to 80 years, DOE has assumed that the entire site would be unavailable for future uses at this time and would be retained for long-term stewardship.	The uncertainty regarding the future use of the Moab site applies to all action alternatives. Decisions on the future use of the Moab site could not be made until surface remediation was complete in 7 to 10 years, and possibly longer, following the issuance of a ROD under either the on-site or off-site disposal alternatives 7 to 10 years. Such future-use decisions would depend in large part on the success of surface remediation, a condition that cannot be known at this time. In addition, it is possible that continuing ground water remediation activities would make the site unavailable for other uses until such activities were complete in 75 to 80 years. The possible uses of the site in 75 to 80 years when ground water remediation actions would be completed are too speculative to analyze meaningfully at this time. For these reasons, future-use scenarios were not analyzed in the EIS.
13.	**Congressional Appropriations** The schedules and budgets presented in the EIS for all the action alternatives assume that Congress would appropriate the money to complete the actions in the proposed time frames.	If Congress did not appropriate the necessary money, the program would not be implemented, and the impacts described under the No Action alternative would persist. Active ground water remediation (on-site and off-site disposal alternatives) could not be implemented, and Colorado River water would remain unprotected indefinitely. Reduced or incremental appropriations could delay realization of protective river water quality until the active ground water remediation was funded and the ground water contaminant plume was intercepted and contained. If any of the activities under the off-site disposal alternative were implemented and then shut down before completion because of appropriated funds being pulled back, there could be higher human health risks to exposed populations than the EIS estimates because of their more prolonged exposure to radiation from the open Moab pile or the incomplete new disposal cell.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
14.	**White Mesa Mill License Amendment** In the EIS, DOE assumes that if the White Mesa Mill alternative were selected, the NRC/State of Utah would amend IUC's current operating license.	DOE presumes that the IUC proposal could be selected (in a ROD) prior to an NRC or State decision to amend the current license. The ROD could stipulate that implementation of the decision would not begin until the requisite amendment was obtained and that if the amendment were denied, the ROD would be modified and another alternative selected. If the White Mesa Mill site were selected and the requisite license amendment subsequently denied, there would be some additional costs due to the delay and need to revise the ROD. Any funds invested in Class III cultural surveys, other White Mesa Mill site characterization studies, and land acquisition would have been wasted.
15.	**Other Contaminants of Concern** The EIS presumes that proposed ground water remediation would extract enough contaminated ground water before it enters the river to achieve a ground water concentration of 3 mg/L ammonia and would also clean up other contaminants to their appropriate and respective cleanup levels. DOE presumes that these other contaminants would reach protective levels within the same time frame that it would take for ammonia to reach protective levels because their concentrations are less elevated above applicable cleanup criteria (e.g., surface water standards), the constituents are less widespread, or they occur at elevated concentrations less frequently. However, DOE acknowledges that there is uncertainty in this assumption due to factors such as differences in solute transport and sorption mechanics.	The consequences of this uncertainty would apply to all action alternatives but would be of greater concern under the on-site disposal alternative. If, after 75 to 80 years of active ground water remediation, it was determined that concentrations of other mill-related contaminants of concern had not been reduced to acceptable levels, ground water remediation would continue until the concentrations reached acceptable levels. The annual generation of 6,600 tons of RRM, the estimated $906,000 in annual ground water treatment costs, and the institutional controls associated with ground water remediation activities would all continue for an indefinite period beyond the currently projected 75 to 80 years.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
16.	**Limited-Use Aquifer** Supplemental standards for ground water quality have been proposed on the assumption that the portion of the aquifer currently and potentially affected by site-derived contamination meets the criteria for limited use as defined in EPA guidance. NRC has suggested that the alluvial aquifer, currently not classified by the State of Utah, may not be suitable for application of supplemental standards on the basis of limited-use criteria. In addition, the State of Utah has indicated that it may have jurisdiction over ground water quality as it relates to protection of ecologically important surface waters. DOE estimates that 97 percent of the upper alluvial aquifer contains water with total dissolved solids (TDS) concentrations greater 3,000 mg/L, which is the threshold for limited-use classification under the Utah ground water classification system, and that over 80 percent of the upper alluvial aquifer contains natural salinity in excess of 10,000 mg/L TDS. Under the provisions of 40 CFR 192, supplemental standards are appropriate for ground water classified as limited use because of naturally occurring poor ambient water quality.	Although DOE presumes that application of supplemental standards is appropriate, should supplemental standards not be implementable, the ground water and surface water protection strategy would need to change and would potentially include strategies such as the application of alternate concentration limits (ACLs) and institutional controls in addition to the active remediation already proposed. The impacts of such alternate strategies would include additional costs and time for ground water modeling and risk analyses to support the ACL application to NRC, long-term monitoring at the points of compliance and points of exposure, and additional regulatory review by NRC and other appropriate agencies. Active ground water cleanup beyond what is currently projected is not likely to be required for the protection of aquatic species.
17.	**Tailings Consolidation** Under the on-site disposal alternative, there is uncertainty regarding the length of time required for the tailings pile to consolidate (settle) sufficiently after loading of surcharge material to allow for final cover emplacement. The EIS schedule acknowledges and allows 2 years for this uncertainty.	This uncertainty applies only under the on-site disposal alternative. If more than 2 years were required for pile consolidation, emplacement of the final cover, and therefore project completion, would be delayed. There would be some additional costs. Adverse visual impacts and worker and public radiation exposure would be prolonged.

Table 2–33. Consequences of Uncertainty (continued)

	EIS Uncertainty/Assumption	Consequences
18.	**Salt Layer Migration** The EIS acknowledges the possible existence of an ammonia salt layer in the pile.	This uncertainty applies only to the on-site disposal alternative and the No Action alternative. If such a layer exists, modeling results indicate that under the on-site disposal alternative, contaminants from the salt layer could reach ground water in approximately 1,100 years (beyond the regulatory design life span of the disposal cell) and could affect ground water and surface water for approximately 440 years. Under the No Action alternative, contaminants from the salt layer could reach ground water within approximately 170 years and could affect it for approximately 50 years. Under the on-site disposal alternative and the No Action alternative, potential future releases of contaminants from the ammonia salt layer in the tailings pile would cause adverse impacts to aquatic species in the Colorado River.
19.	**Use of Tandem Trucks** On the basis of DOE's experience and preliminary discussions with UDOT, the EIS assumes that overweight (tandem truck) permits would be required and could be issued. On the basis of prior DOE experience with tailings hauls, it does not appear reasonable that a single truck haul would be considered by contractors responding to the bid package. However, it is possible that Utah would not issue the requisite oversize permits.	This uncertainly primarily affects the off-site truck haul alternative, although to a lesser degree it also affects borrow material transport under all action alternatives and transport of oversized debris under the rail or pipeline off-site disposal alternatives. If the State of Utah did not permit the use of tandem trucks, then significant additional adverse impacts would be associated with the off-site truck haul disposal alternative. The estimated daily truck trips to haul contaminated materials and borrow materials could increase substantially, as would fuel use, traffic accidents, traffic-related air pollution, and truck driver exposures to radiation.

However, the Utah Department of Environmental Quality disagrees with DOE's selection of the acute standard and has stated that the chronic and acute standard should be the same (0.6 mg/L). The consequences of the State's position could lengthen the duration of ground water remediation and were discussed in more detail in Item 2 of Table 2–33.

In some instances, the areas of controversy reflect an opinion on which of the alternative actions DOE should select as its preferred alternative. For example, the State of Utah feels that the tailings should be moved to an off-site location because of uncertainties in predicting river migration and the ability of on-site disposal to meet protective aquatic standards. The City of Moab and Grand County feel that the tailings pile should be moved to Klondike Flats for aesthetic and other reasons.

The Ute community expressed a strong preference that the tailings pile should not be moved to White Mesa Mill due to the high potential for adverse impacts to cultural resources, traditional cultural properties, and other impacts. As downstream users, the Town of Bluff also objects to disposal at White Mesa Mill. However, San Juan County and the City of Blanding have stated that the future reuse of a slurry pipeline to White Mesa Mill would offer substantial economic benefits to agriculture in the region.

There are also some areas of technical disagreement regarding long-term site risks. These risks are associated with uncertainties in processes potentially occurring over hundreds or thousands of years that are not amenable to short-term resolution. For example, professional differences of opinion with the State of Utah on river migration, or transport of contaminants under the Colorado River to the Matheson Wetlands Preserve can be resolved with certainty only through long-term monitoring. Characterization of these issues and the potential consequences of these differing opinions with regard to environmental impacts are discussed in Table 2–33. While acknowledging these as areas of scientific controversy, DOE does not believe that it is necessary to conclusively resolve these technical controversies before making informed site remediation decisions. DOE will, however, incorporate protocols into its ROD, which will be elaborated on in a subsequent remedial action plan, to require long-term processes to be monitored in a manner that would allow timely remedial action to be taken if DOE's assumptions were subsequently shown to be in error.

DOE recognizes each of these perspectives and, as appropriate, has incorporated them into the analysis of impacts. DOE will take these views into account when it makes its decision on the ultimate disposition of the tailings pile following the issuance of the final EIS.

The primary issue to be resolved is whether to dispose of the Moab uranium mill tailings pile on-site or off-site. If the off-site disposal alternative were selected, DOE must decide which of the three off-site disposal locations should be selected and which mode of transportation (truck, rail, or slurry pipeline) should be used. Ground water remediation would occur under any of the action alternatives. Selection of the No Action alternative for either surface or ground water remediation would not fulfill DOE's obligations under federal law to protect human health and the environment.

2.7.2 National Academy of Sciences Review

The Floyd D. Spence Act required that a remediation plan be prepared to evaluate the costs, benefits, and risks associated with various remediation alternatives, including "removal or treatment of radioactive or other hazardous materials at the site, ground water restoration, and long-term management of residual contaminants." The Act further stipulated that the draft plan be presented to NAS for review. NAS was directed to provide "technical advice, assistance, and recommendations" for remediation of the Moab site. Under the Act, the Secretary of Energy is required to consider NAS comments before making a final recommendation on the remedy. If the Secretary prepares a remediation plan that is not consistent with the recommendations of the NAS, the Secretary must submit to Congress a report explaining the reasons for deviation from the NAS recommendations.

The *Preliminary Plan for Remediation* (DOE 2001b) was completed in October 2001 and forwarded to NAS. The National Research Council, the chief operating arm of NAS, formed a committee of expert volunteers to review the draft plan and provide technical advice and recommendations for a remedy at the Moab site. The committee held a fact-gathering meeting in Moab on January 14–15, 2002; this meeting included a session for public input. The committee completed its report on June 11, 2002, and conducted a public meeting in Moab and released the report on the same date.

The NAS report concluded that existing scientific and technical data were insufficient to support a decision. Specifically, the committee provided four principal reasons for not selecting a remedial action alternative at the time the report was issued.

The first reason stated that "The pile, the Moab site, and alternative sites for a relocated disposal cell have not been characterized adequately." Since preparation of the *Preliminary Plan for Remediation*, additional characterization of the tailings pile and the Moab site, which was not available at the time of the NAS review, has been completed and is presented in the SOWP (DOE 2003b). In addition, numerous other reports have been acquired or generated by DOE that are cited as references throughout this EIS and that provide sufficient characterization of the three off-site alternatives to support the analyses in this EIS and future DOE decision-making.

The second reason stated that "Options for implementing the two primary remediation alternatives have not all been identified or sufficiently well defined." More detailed and complete options for implementing the two primary remediation alternatives, stabilize-in-place or off-site disposal, have been identified and defined in the EIS. For example, three off-site alternatives have been added to the scope of this EIS where, in contrast, the *Preliminary Plan for Remediation* only considered one off-site alternative in any detail. Pre-conceptual facilities configurations, transportation scenarios, labor and resource requirements have all been defined and presented to support comparative impacts analysis. DOE is confident that the configuration and definition of all the alternatives is much more robust that originally presented in the *Preliminary Plan for Remediation* and sufficient to support sound decision-making.

The third reason stated that "Risks, costs, and benefits of the major alternatives have not been adequately characterized and estimated." Human and ecological risks, long- and short-term environmental impacts, costs, and benefits of the major alternatives, which were not completely developed in the *Preliminary Plan for Remediation*, have been fully developed and evaluated in the EIS. This includes assessment of potential impacts of catastrophic failure of the disposal cell for the on-site stabilization alternative should DOE's conclusions regarding river migration prove to be incorrect.

The fourth reason stated that "Long-term management implications for each option have not been described." The scope and costs of the long-term stewardship requirements associated with each option have been more fully developed and evaluated in the EIS. Included in this evaluation are the long-term ground water remedial action costs and long-term stewardship costs for annual surveillance and maintenance. The impacts of catastrophic failure should long-term surveillance and engineering controls fail are also included in the EIS to support informed decision-making.

NAS also advised that decisions involving risk management should involve stakeholders from the earliest phases of defining the problem through the final decision. NAS noted that involving the public has particular value at Moab because of the anticipated long duration of the cleanup. To date, DOE's efforts toward public involvement have included public scoping meetings, periodic project update public briefings, publication of project documents on a project website, and presentations to city council meetings. DOE has also included federal and state agencies along with cities, towns, counties, and tribes as cooperating agencies in the development of the EIS through briefings, data submittals to cooperating agencies, and reviews of preliminary drafts. Section 1.6 presents a discussion of these activities and the differing opinions expressed by the cooperating agencies.

In addition, the National Research Council committee recommended further study and evaluation of a wide range of technical areas before DOE makes decisions on the remediation of the Moab site. Table 2–34 presents a summary of these recommendations. NAS did not provide a recommendation on a disposal alternative. Since the issuance of the NAS report, DOE has integrated the NAS recommendations for further study into ongoing site investigations and has utilized this newly gained knowledge in the analyses performed for this EIS.

NAS has confirmed that their role in the Moab project ended with the issuance of their report, that NAS met their responsibilities under the Act, and that unless directed by Congress, NAS will not be reviewing the EIS (NAS 2004). DOE has considered NAS findings and recommendations in developing this EIS. Specifically, Table 2–34 lists key NAS recommendations, DOE's proposed resolution to findings and recommendations, and the chapter and section of the EIS in which they are addressed.

2.7.3 Costs

To support future decision-making, DOE has estimated the costs of the alternatives analyzed in this draft EIS (Table 2–35). The estimates, which are in 2003 dollars, include the total costs for surface remediation, ground water remediation, and long-term surveillance and monitoring of the disposal cell. The estimates assume that ground water remediation and long-term surveillance and monitoring would continue for 80 years under the on-site disposal alternative and for 75 years under the off-site disposal alternative, although DOE acknowledges that up to $35,000 in annual costs for disposal cell surveillance and monitoring could continue in perpetuity. The estimates assume implementation of a single work shift schedule; however, the estimates would be essentially the same if a double work shift were implemented because a double shift would not involve overtime costs, but only a compressed schedule for completing the same work. The cost estimate accuracy, as defined by ANSI and the Association for the Advancement of Cost Engineering, is a budget estimate and is expected to fall within the range of –15 percent to +30 percent. However, DOE acknowledges that additional uncertainties, such as land acquisition and impact mitigation costs, are inherent in these estimates.

Table 2–34. Key NAS Recommendations for Assessing Remedial Action Alternatives for the Moab Site

Recommendation	Proposed Resolution	EIS Chapter/Section
Use bounding analysis to frame the major issues.	Incorporate bounding analysis throughout the EIS.	All sections
Evaluate the impacts of a potential failure of the tailings pile.	Include an evaluation of catastrophic failure of a disposal cell at the Moab site.	Chapter 4.0, Section 4.1.17, "Disposal Cell Failure from Natural Phenomena"
Rely on the experience gained from previous DOE projects and the UMTRA Project.	Use overall experience and lessons learned from DOE's uranium mill tailings cleanup programs, especially construction of uranium mill tailings disposal cells, Long-Term Surveillance and Maintenance Program annual inspections of disposal cells, and cleanup of UMTRA Project vicinity properties.	Chapter 2.0, Sections 2.1.1, "Construction and Operations at the Moab Site," 2.1.2, "Characterization and Remediation of Vicinity Properties," 2.1.5, "Resource Requirements"; Chapter 4.0, sections titled "Construction and Operations Impacts at the Moab Site," "Impacts from Characterization and Remediation of Vicinity Properties," "Monitoring and Maintenance Impacts"; and Appendix B, "Assumed Disposal Cell Cover Conceptual Design and Construction."
Improve the understanding of the potential performance of the disposal cell.	Conduct a more detailed evaluation of physical conditions at the proposed disposal sites with respect to geology, soils, climate and meteorology, ground water, and surface water; design a disposal cell that would perform satisfactorily under worst-case conditions at the proposed sites.	Chapter 3.0, Geology—Sections 3.1.1, 3.2.1, 3.3.1, 3.4.1; Soils—Sections 3.1.2, 3.2.2, 3.3.2, 3.4.2; Climate and Meteorology—Sections 3.1.5, 3.2.3, 3.3.4, 3.4.4; Ground Water—Sections 3.1.6, 3.2.4, 3.3.5, 3.4.5; Surface Water—Sections 3.1.7, 3.2.5, 3.3.6, 3.4.6; Appendix B, "Assumed Disposal Cell Cover Conceptual Design and Construction."
Evaluate impacts from institutional controls, including failure.	Evaluate institutional controls with respect to risk to workers and members of the public exposed to contaminants at the proposed disposal sites.	Chapter 4.0, "Human Health"—Sections 4.1.15, 4.2.15, 4.3.15, 4.4.15, 4.1.17, "Disposal Cell Failure from Natural Phenomena"; Appendix D, "Human Health."
Refine the initial cost estimates for the major alternatives.	Provide more detailed cost estimates in 2003 dollars.	Chapter 2.0, Section 2.7.3, "Costs"; Chapter 4.0, "Socioeconomics"—Sections 4.1.14, 4.2.14, 4.3.14, 4.4.14.
Examine the effectiveness of long-term management.	Prepare a risk assessment to evaluate several aspects of the two major alternatives—cap in place and off-site disposal.	Chapter 4.0, "Human Health"—Sections 4.1.15, 4.2.15, 4.3.15, 4.4.15, 4.1.17, "Disposal Cell Failure from Natural Phenomena"; Appendix D, "Human Health."

2.7.3.1 On-Site Versus Off-Site Disposal Alternative Comparison

Depending on the off-site disposal cell location and mode of transportation, off-site disposal would cost approximately 63 to 118 percent more than on-site disposal. In absolute terms, off-site disposal would cost approximately $158 million to $294 million more than on-site disposal, depending on the off-site disposal location and mode of transportation.

2.7.3.2 Off-Site Transportation Options Comparison

Among the three transportation options, truck haul would be the least expensive and slurry pipeline the most expensive. The cost difference between rail and slurry pipeline would be less than 2 percent. Truck transportation would cost approximately 10 to 15 percent less than either rail or slurry pipeline.

Table 2–35. Estimated Lifetime Cost of Analyzed Disposal Alternatives

Remedial Action Component	Stabilize In Place	Klondike Flats			Crescent Junction			White Mesa	
		Truck	Rail	Pipeline	Truck	Rail	Pipeline	Truck	Pipeline
Site Characterization	$1.6	$1.6	$1.6	$1.6	$1.6	$1.6	$1.6	$1.6	$1.6
Env. Health & Safety/NEPA	$6.4	$16.8	$17.1	$9.7	$16.8	$17.1	$9.7	$16.8	$5.7
Remedial Action Design	$2.0	$2.0	$2.0	$4.8	$2.0	$2.0	$6.0	$2.0	$7.1
Site Acquisition	NA	NA	NA	NA	NA	NA	NA	NA	NA
Remedial Action Field Management	$9.9	$9.6	$9.6	$9.6	$9.6	$9.6	$9.6	$9.6	$6.6
Site Preparation	$1.7	$35.2	$40.4	$76.2	$31.8	$40.9	$86.3	$31.5	$103.0
Tailings Handling	$4.7	$110.6	$158.1	$131.8	$126.1	$169.6	$133.8	$198.9	$171.0
Cover Material	$41.0	$38.9	$38.9	$38.9	$30.3	$30.3	$30.3	$29.9	$28.2
Erosion Protection	$6.0	$4.1	$4.1	$4.1	$4.3	$4.3	$4.3	$3.4	$3.5
Site Restoration	$7.4	$6.0	$7.0	$7.1	$5.7	$6.7	$8.5	$12.6	$17.0
All Other Construction Costs[a]	$48.8	$54.6	$56.7	$54.7	$54.6	$56.7	$54.7	$54.9	$59.0
Surveillance & Maintenance (Including Ground Water O&M)	$75.3	$69.9	$69.9	$69.9	$69.9	$69.9	$69.9	$69.9	$69.9
Subtotal	**$204.7**	**$349.4**	**$405.3**	**$408.4**	**$352.7**	**$408.6**	**$414.6**	**$431.1**	**$472.6**
Vicinity Property Design	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0
Vicinity Property Construction	$9.2	$9.2	$9.2	$9.2	$9.2	$9.2	$9.2	$9.2	$9.2
Technical Assistance Contract Project Management	$11.3	$10.6	$10.6	$10.6	$10.6	$10.6	$10.6	$10.6	$10.6
Total	**$226.1**	**$370.2**	**$426.1**	**$429.2**	**$373.5**	**$429.4**	**$435.4**	**$451.9**	**$493.4**
Contingency @ 10%	$22.6	$37.0	$42.6	$42.9	$37.3	$42.9	$43.5	$45.2	$49.3
Grand Total[b]	**$248.8**	**$407.2**	**$468.7**	**$472.1**	**$410.8**	**$472.3**	**$479.0**	**$497.1**	**$542.7**

[a] Costs include other pre-remediation and remediation expenditures for surface actions as well as ground water characterization, design, and initial construction not normally included with UMTRA surface remediation.

[b] Costs do not include pre-ROD activities (e.g. EIS, pre-ROD site maintenance, and interim actions).

2.7.3.3 Off-Site Disposal Cell Locations Comparison

The costs for off-site disposal at the Klondike Flats and Crescent Junction sites would be comparable, differing less than 2 percent regardless of the mode of transportation. Consistent with this, the estimates indicate that transport distance is not a key factor in cost for the off-site disposal alternatives. The approximate ratio of the distances of the Klondike Flats, Crescent Junction, and White Mesa Mill sites from the Moab site is 1:1.7:4.7. However, despite the almost 5 times longer distance to White Mesa Mill, truck transportation would cost only 22 percent more for the White Mesa Mill site than for the Klondike Flats site, and slurry transportation would cost only 15 percent more. Nonetheless, the absolute increase in cost under the White Mesa Mill off-site disposal alternative would be substantial. Compared to the cost to ship to the Klondike Flats site, shipping to the White Mesa Mill site would cost $90 million more for truck transport and $71 million more for pipeline transport. In contrast, the absolute increase in cost for the Crescent Junction site over the Klondike Flats site would be only about $3 million to $7 million, depending on the mode of transportation.

2.8 References

10 CFR 1022. U.S. Department of Energy, "Compliance with Floodplain and Wetlands Environmental Review Requirements."

10 CFR 40. U.S. Nuclear Regulatory Commission, "Domestic Licensing of Source Material."

40 CFR 192. U.S. Environmental Protection Agency, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings."

40 CFR 1500–1508. Council on Environmental Quality, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act."

49 CFR 171. Research and Special Programs Administration, Department of Transportation, "General Information, Regulations, and Definitions."

49 CFR 172. Research and Special Programs Administration, Department of Transportation, "Hazardous Materials Table, Special Provisions, Hazardous Materials Communications, Emergency Response Information, and Training Requirements."

49 CFR 173. Research and Special Programs Administration, Department of Transportation, "Shippers—General Requirements for Shipments and Packaging."

49 CFR 177 Research and Special Programs Administration, Department of Transportation, "Carriage by Public Highway."

62 FR 8693–8704, U.S. Department of Energy, "Record of Decision for the Tank Waste Remediation System, Hanford Site, Richland, Washington," *Federal Register*, February 26, 1997.

ANSI/ASME (American National Standards Institute/American Society of Mechanical Engineers), 1989. *Slurry Transportation Piping Systems*, standard B31.11-89, reaffirmed 1998.

Bredehoeft, J.D., 2003. "From Models to Performance Assessment: The Conceptualization Problem," in *Ground Water*, 41(5):571–577.

DOE (U.S. Department of Energy), 1988. *Vicinity Properties Management and Implementation Manual*, UMTRA DOE/AL-050601, U.S. Department of Energy, Grand Junction, Colorado, March.

DOE (U.S. Department of Energy), 1996a. *Final Programmatic Environmental Impact Statement for the Uranium Mill Tailings Remedial Action Ground Water Project*, DOE/EIS-0198, U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico, October.

DOE (U.S. Department of Energy), 1996b. *In-situ Vitrification*, fact sheet, U.S. Department of Energy, Brookhaven National Laboratory, available at: http://www.bnl.gov/erd/Surface/ou1/ISV-facts.pdf.

DOE (U.S. Department of Energy), 1998. *Demonstration Project Report for the Transportable Vitrification System at the Oak Ridge East Tennessee Technology Park*, K/WM–186, Vol. I, prepared by East Tennessee Technology Park, Oak Ridge, Tennessee, May.

DOE (U.S. Department of Energy), 2001a. Internal DOE memorandum to James Owendoff (EM–2), from Joyce Jamie (EM–34), "Applicability of Soil Washing Technology to Moab Mill Tailings," dated June 1.

DOE (U.S. Department of Energy), 2001b. *Preliminary Plan for Remediation,* draft, GJO-2001-269-TAR, U.S. Department of Energy, Grand Junction, Colorado, October.

DOE (U.S. Department of Energy), 2002a. *Fugitive Dust Control Plan for the Moab, Utah, UMTRA Project Site,* GJO-2002-301-TAR, U.S. Department of Energy, Grand Junction, Colorado, March.

DOE (U.S. Department of Energy), 2002b. *Work Plan for Implementation of the Initial Action in the Sandbar Area Adjacent to the Moab Project Site,* GJO-2002-299-TAR, U.S. Department of Energy, Grand Junction, Colorado, March.

DOE (U.S. Department of Energy), 2003a. *Migration Potential of the Colorado River Channel Adjacent to the Moab Site,* U.S. Department of Energy, Grand Junction, Colorado, March.

DOE (U.S. Department of Energy), 2003b. *Site Observational Work Plan for the Moab, Utah, Site*, GJO-2003-424-TAC, U.S. Department of Energy, Grand Junction, Colorado, December.

EPA (U.S. Environmental Protection Agency), 1971. Correspondence: Joint Committee on Atomic Energy (U.S. congress) and EPA: Titled: Environmental Protection Agency Progress Report on Uranium Mill Tailings Activities, December 31.

EPA (U.S. Environmental Protection Agency), 1988. *Guidelines for Ground-Water Classification Under the EPA Ground Water Protection Strategy,* PB95-169603, U.S. Environmental Protection Agency, Washington, D.C., June.

EPA (U.S. Environmental Protection Agency), 1995. *Cost Performance Report: Soil Washing at the King of Prussia Technical Corporation Superfund Site, Winslow Township, New Jersey*, Office of Solid Waste and Emergency Response, March.

EPA (U.S. Environmental Protection Agency), 1997. *Cost Performance Report: In Situ Vitrification at the Parsons Chemical/ETM Enterprises Superfund Site, Grand Ledge, Michigan*, Office of Solid Waste and Emergency Response, July.

EPA (U.S. Environmental Protection Agency), 1999. *1999 Update of Ambient Water Quality Criteria for Ammonia*, EPA-822-R99-014, U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, D.C., December.

EPA (U.S. Environmental Protection Agency), 2001. *Abstracts of Remediation Case Studies*, Volume 5, EPA542–R–01–008, Federal Remediation Technologies Roundtable, May.

FRTR (Federal Remediation Technologies Roundtable), 2001. "Cost and Performance, Catalog of Case Studies," www.frtr.gov/cost/index.html, October 17.

IUC (International Uranium Corporation), 2003. "Overview of White Mesa Mill Operations and Moab Tailings Relocation Project," presentation for the U.S. Department of Energy, February.

Mayne, P.W., and J. Beaver, 1996. "High Temperature Plasma Vitrification of Geomaterials," *Electronic Journal of Geotechnical Engineering*, Volume 1, Fall.

NAS (National Academy of Sciences), 2003. Letter to Donald R. Metzler, U.S. Department of Energy, Grand Junction, Colorado, from Micah D. Lowenthal, Senior Program Officer, National Academy of Sciences, dated September 22.

NRC (U.S. Nuclear Regulatory Commission), 1989. *Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers*, Regulatory Guide 3.64 (Task WM 503-4), U.S. Nuclear Regulatory Commission, Washington D.C.

NRC (U.S. Nuclear Regulatory Commission), 1999. *Final Environmental Impact Statement Related to Reclamation of the Uranium Mill Tailings at the Atlas Site, Moab, Utah,* NUREG-1531, Office of Nuclear Material Safety and Safeguards, Washington, D.C., March.

NRC (U.S. Nuclear Regulatory Commission), 2002. *Design of Erosion Protection for Long-term Stabilization,* NUREG-1623, U.S. Nuclear Regulatory Commission, Washington, D.C.

Pickett, J.B., S.W. Norford, J.C. Musall, and D.J. Bills, 2000. *Vitrification and Privatization Success*, Rev. 1,WSRC–MS–2000–00305, Westinghouse Savannah River Company.

PSI (Pipeline Systems Incorporated), 2003. *Moab Tailings Pipeline Transportation Conceptual Study*, Document No. 1028-G-G-002, June.

Stormont, J.C., and C.E. Morris, 1998. "Method to Estimate Water Storage Capacity of Capillary Barriers," *Journal of Geotechnical and Geoenvironmental Engineering*, 124(4):297–392, American Society of Civil Engineers, Reston, Virginia, April.

UAC (Utah Administrative Code), 2000. "Emission Standards: Fugitive Emissions and Fugitive Dust," *Utah Administrative Code* R307-205, effective January 1, 2000.

USF&WS (U.S. Fish and Wildlife Service), 2002. "Recovery Goals for Four Endangered Fishes of the Colorado River," available at: http://www.r6.fws.gov/crrip/rg.htm.

USGS (U.S. Geological Survey), 2002. *A Site-Specific Assessment of the Risk of Ammonia to Endangered Colorado Pikeminnow and Razorback Sucker Populations in the Upper Colorado River Adjacent to the Atlas Mill Tailings Pile, Moab, Utah,* Final Report to the Fish and Wildlife Service, Division of Environmental Quality, Salt Lake City, Utah, United States Geological Survey, December.